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THE INFLUENCE OF EXPANDED MEASUREMENT UNCERTAINTY IN THE STATEMENT OF CONFORMITY FOR HAND TORQUE TOOLS CALIBRATION

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ABSTRACT
The BAS EN ISO/IEC 17025 standard gives the laboratory the opportunity to accredit the statement of conformity. The statement of conformity is provided in accordance with the specification, standard or costumer requirement. Prior to issuing the statement of conformity, the accredited laboratory, in cooperation with the costumer, must document the decision rule to be applied taking into account the level of risk associated with the decision rule. This paper describes the procedure for calibrating hand torsion tools with measurement uncertainty assessment, a practical example of calibration with a statement of conformity in terms of two possible decision rules and the risk that will be accepted by the laboratory or the costumer.

1. INTRODUCTION

When a statement of conformity to specification or standard is provided, the laboratory shall document the decision rule employed, taking into account the level of risk (such as false accept and false reject and statistical assumptions) associated with the decision rule employed, and apply the decision rule. Where the decision rule is prescribed by the customer, regulations or normative documents, a further consideration of the level of risk is not necessary, The laboratory shall report on the statement of conformity, such that the statement clearly identifies to which results the statement of conformity applies, which specifications, standards, part of standard thereof are met or not met and the decision rule applied [1].

2. REPORTING RELATED TO THE STATEMENT OF CONFORMITY

If a costumer requires the statement of conformity to a specification or standard, the specification or standard and the decision rule shall be clearly defined in the offer and/or contract. If the decision rule is already contained in the specification or standard, this shall be communicated to the costumer through the offer. The costumer shall also define whether the decision rule shall be taken into account when making the statement of conformity and shall assume the risk of false acceptance or false rejection of the results.

2.1 Compliance of results with limit values – measurement uncertainty is not taken into account when provide the statement of conformity

When reporting on the statement of conformity, if a decision rule is defined - measurement uncertainty will not be taken into account, when issuing the statement, two cases are possible:

- the measurement result is in the acceptance zone,
- the measurement result is in the rejection zone

For the two possible cases mentioned, the statement of conformity shall read:

1. Based on the measurement results, the calibration item complies with the requirements prescribed in the technical specification/standard.
2. Based on the measurement results, the calibration item is non-compliant or does not comply with the requirements prescribed in the technical specification/standard.

2.2 Compliance of results with limit values – measurement uncertainty is taken into account when provide the statement of conformity

When the measurement result, which includes the measurement uncertainty, is compared with the limit of the specification or standard or the interval (lower and upper limit) of the specification or standard, four cases can be distinguished, Figure 1:

- the measurement result including the measurement uncertainty is in the acceptance zone,
- the measurement result including the measurement uncertainty is in the rejection zone,
- the measurement result is in the acceptance zone but including the measurement uncertainty partially enters the rejection zone, i.e. leaves the acceptance zone,
- the measurement result is in the rejection zone but including the measurement uncertainty partially enters the acceptance zone [2].

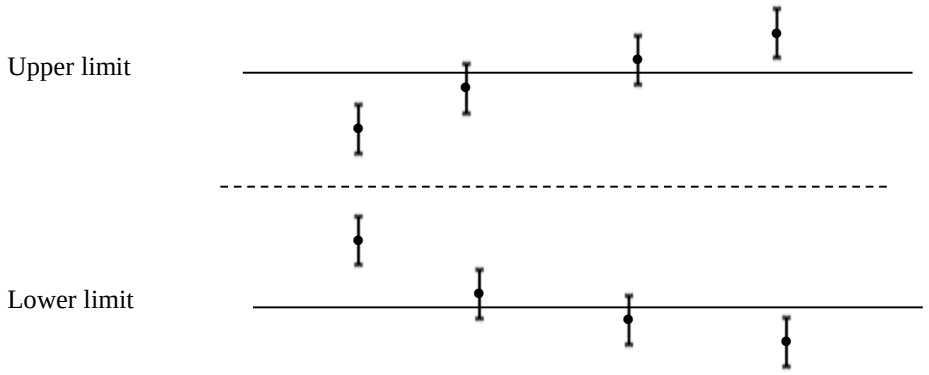

Figure 1. Compliance of results, with included measurement uncertainty, with limit values

The first two cases are completely clear. For the third and fourth cases the decision is not clear because the uncertainty interval exceeds the upper and lower allowed limits/acceptance zones, respectively. In the third and fourth cases in the conformity assessment, there is a probability of two types of wrong decisions, one for the customer and the other for the laboratory. The risk of wrongly accepting or wrongly rejecting the results is assumed by the customer because the decision rule is always prescribed by the customer.

For the four possible cases mentioned, the statement of conformity would read:

1. Based on the measurement results, the calibration item complies with the requirements prescribed in the technical specification/standard.
Note: All measurement results including measurement uncertainty are within the reference value limit with a confidence level of 95%.

2. Based on the measurement results, the calibration item complies with the requirements prescribed in the technical specification/standard.
Note: The compliance of the measurement results with the reference values cannot be confirmed with a confidence level of 95%, which means that there is a possibility that the measurement result is outside the limits of the reference values.
3. Based on the measurement results, the calibration item does not comply with the requirements prescribed in the technical specification/standard.
Note: The non-compliance of the measurement results with the reference values cannot be confirmed with a confidence level of 95%, which means that there is a possibility that the measurement result is within the limits of the reference values.
4, Based on the measurement results, the calibration item is non-compliant with the requirements prescribed in the technical specification/standard/regulation.
Note: The measurement result including the measurement uncertainty is outside the reference value limit with a confidence level of 95%.

The measurement results that are an integral part of the certificate/calibration report containing the statement of conformity shall be clearly identified, i.e. it is clear to which results the statement applies, which results meet or do not meet the requirements prescribed in the relevant specification or standard and which decision rule has been applied.

3. CALIBRATION OF TORQUE WRENCH

Calibration of torque wrenches is carried out in accordance with the requirements of the BAS EN ISO 6789-1:2018 standard [3], which refers to requirements and methods for design conformance testing and quality conformance testing, i.e. minimum requirements for the declaration of conformity, and in accordance with the requirements of the BAS EN ISO 6789-2:2018 standard [4], which refers to requirements for calibration and determination of measurement uncertainty.

3.1 Calibration procedure

Calibration conditions for different types and classes of torque wrenches are prescribed by the BAS EN ISO 6789-1 standard. This paper provides an example of calibration for a torque wrench type II class A – adjustable with scale or display.
Torque wrenches are calibrated at the lowest value and then at approximately 60% and 100% of the maximum torque value by checking each calibration point/value on the torque wrench five times. According to table 4 of the BAS EN ISO 6892-1 standard, the maximum permissible error for torque wrenches of type II, class A is ±6% for torque values ≤10 Nm and ±4% for torque values >10 Nm.

3.2 Torque wrench data

A torque wrench with a measuring range of 400 Nm has been calibrated, calibration range from 80 Nm to 400 Nm, serial number 121433381, manufacturer STAHLWILLE, type MANOSKOP 730N/40 with a square drive and a micrometer scale with a secondary scale. On the main scale, the values between adjacent marks are 20 Nm and on the secondary scale 2 Nm. The torque wrench resolution is 1 Nm.

3.3 Statement of conformity in accordance with BAS EN ISO 6892-1 and the decision rule "Measurement uncertainty is not taken into account when provide the statement of conformity"

The following standards were used for torque wrench calibration:

1. Measuring amplifier MX440B (serial number 0009E5012ACD) in a measuring chain with: 10 kN force transducer (serial number H44272, certificate number ZA_TRC_4_03.04_168 dated 08.05.2023, issued by TRCpro Petrovaradin, Serbia, accreditation ATC 02-053) and 500 N force transducer (serial number 58971, certificate number ZA_TRC_4_03.01_167 dated 08.05.2023, issued by TRCpro Petrovaradin, Serbia, accreditation ATC 02-053).
2. Standard lever of the torque wrench calibration device (serial number 071749, certificate number 1281/24 dated 04.07.2024, issued by BNT Novi Travnik, Bosnia and Herzegovina, accreditation LK-05-02).

The results of the calibration with the torque wrench deviation for the calibration points 80 Nm, 240 Nm and 400 Nm are given in Table 1, and a graphical representation of the deviation is shown in Figure 2.

Table 1. Calibration results

Torque value on wrench (Nm)	Torque value on standard and deviation									
	Value (Nm)	Deviation (%)	Value (Nm)	Deviation (%)	Value (Nm)	Deviation (%)	Value (Nm)	Deviation (%)	Value (Nm)	Deviation (%)
80	83,01	-3,76	83,03	-3,79	82,44	-3,05	82,99	-3,74	82,77	-3,46
240	246.03	-2,51	245,54	-2,31	242,6	-1,08	242,11	-0,88	240,64	-0,27
400	404,17	-1,04	405.68	-1,42	405,68	-1,42	404,66	-1,16	404.17	-1,04

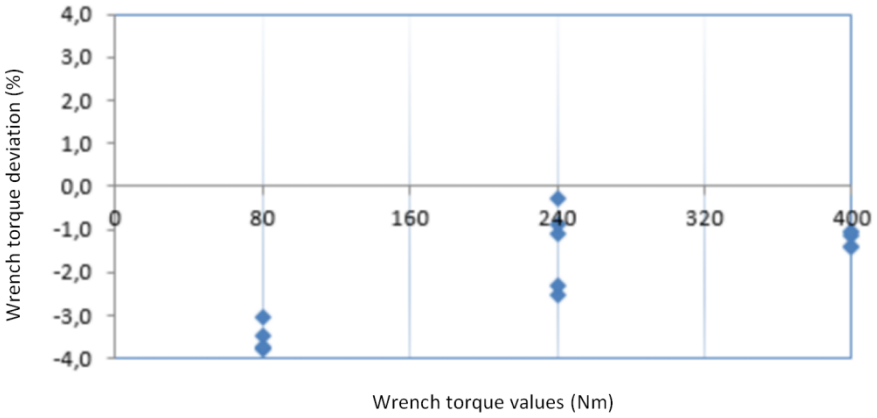

Figure 2. Graphic representation of torque wrench deviation

The declaration of conformity for the calibrated torque wrench reads:
Maximum measurement error of the standard a_S: ±0.10%
Measurement uncertainty interval of the standard W': ±0.174%
The measurement error of the standard is less than 1/4 of the maximum permissible deviation of the torque wrench
The deviation of the torque wrench, serial number 121 433 381 in the measuring range 80 Nm to 400 Nm is in accordance with point 5.1.5 of the BAS EN ISO 6789-1:2018 standard (the maximum permissible deviation for a torque wrench type II, class A is ±4%).

3.4 Statement of conformity in accordance with BAS EN ISO 6892-1 and the decision rule "Measurement uncertainty is taken into account when provide the statement of conformity"

The estimated standard contributions to the measurement uncertainty, the value of the combined and expanded uncertainty are given in Table 2.

Table 2. Estimated measurement uncertainty

Torque value on wrench (Nm)	Standard uncertainty (%)							u_c, %	U %
	w_{re}	w_r	w_{rep}	w_{od}	w_{int}	w_l	w_{std}		
80	0,140	0,374	0,353	0,601	0,724	0,029	0,04	1,082	2,122
240	0,432	0,122	0,115	0,196	0,236	0,009	0,03	0,556	1,112
400	0,085	0,073	0,069	0,117	0,141	0,005	0,06	0,228	0,456

where is:
w_{re} - *standard uncertainties relate to repeatability*
w_r - *standard uncertainties relate to resolution*
w_{rep} - *standard uncertainties relate to reproducibility*
w_{od} - *standard uncertainties relate to geometric effects of the output drive*
w_{int} - *standard uncertainties relate to geometric effects of the interface*
w_l - *standard uncertainties relate to variation of the torque loading point*
w_{std} - *standard uncertainties relate to transfer standard*
u_c - *combined uncertainty*
U - *expanded uncertainty*
The reported expanded uncertainty of measurements is stated as the standards uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.The standard uncertainty of measurement has been determined in accordance with EA 4-02 document.

The Mechanical Calibration Laboratory has confirmed the calibration measurement capability of 1% for the measurement range from 10 Nm to 500 Nm, which is stated in the accreditation supplement LK-02-01. For this reason, the value of the expanded measurement uncertainty for the calibration point 400 Nm is 1%.
Table 3 gives the mean values of the torque wrench deviations, and Figure 3 shows a graphical representation of the mean value of the deviations with the measurement uncertainty included.

Table 3. Mean deviation values of the wrench

Torque value on wrench (Nm)	Mean value of the deviation of the wrench (%)
80	-3,59
240	-1,44
400	-1,23

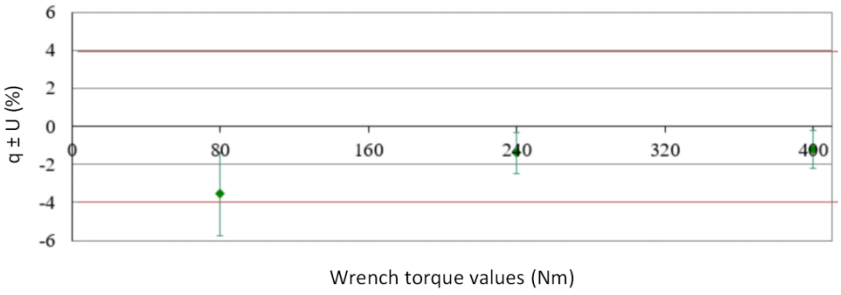

Figure 3. Graphic representation of the mean deviation wrench value

The mean value of the torque wrench deviation of five measurements for the calibration point 80 Nm falls within the acceptance limits of 4 % for the calibrated torque wrench type II class A. If the decision rule that the expanded measurement uncertainty is taken into account in the evaluation is applied to the evaluation of the measurement results, for the measurement range from 80 Nm to <240 Nm there is a possibility that the measurement result is outside the acceptance limit with a confidence level of 95 %. In the measurement range from 240 Nm to 400 Nm, all measurement results with included measurement uncertainty with a confidence level of 95% are within the acceptance limit for a torque wrench type II, class A. In such a case, the Statement would read:

Based on the measurement results, the torque wrench serial number 121 433 381 in the measuring range from 240 Nm to 400 Nm, complies with the requirements prescribed in the technical specification/standard.
Note: All measurement results including measurement uncertainty are within the reference value limits with a confidence level of 95%.

Based on the measurement results, the torque wrench serial number 121 433 381 in the measuring range from 80 Nm to <240 Nm complies with the requirements prescribed in the technical specification/standard.
Note: The compliance of the measurement results with the reference values cannot be confirmed with a confidence level of 95%, which means that there is a possibility that the measurement result is outside the reference value limits.

4. CONCLUSION

If a customer requires the statement of conformity to a specification or standard, the specification or standard and the decision rule shall be clearly defined in the offer and/or contract. After signing the contract, the technical specification and decision rule may not be changed by either the customer or the laboratory.

When the statement of conformity is issued with the decision rule "Measurement uncertainty shall not be taken into account in the evaluation of the results" there are two possible cases:
- The measurement results are in the acceptance zone,
- The measurement results are in the rejection zone.

When the statement of conformity is issued with the decision rule "Measurement uncertainty shall be taken into account when evaluating the results" there are 4 possible cases:
- The measurement result including the measurement uncertainty is in the acceptance zone,
- The measurement result including the measurement uncertainty is in the rejection zone,
- The measurement result is in the acceptance zone but including the measurement uncertainty partially enters the rejection zone, i.e. leaves the acceptance zone,
- The measurement result is in the rejection zone but including the measurement uncertainty partially enters the acceptance zone.

5. REFERENCES

[1] Standard BAS EN ISO/IEC 17025: 2018
[2] www.splaboratorija.rs/wp-content/uploads/2023/01/pravila-odlucivanja.pdf (24.02.2025)
[3] Standard BAS EN ISO 6789-1:2018
[4] Standard BAS EN ISO 6789-2:2018